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RISK FACTORS ASSOCIATED WITH NUTRITIONAL RICKETS AMONG CHILDREN AGED 2 TO 36 MONTHS OLD IN THE GAZA STRIP: A CASE CONTROL STUDY

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Abstract: This study assessed the various risk factors associated with nutritional rickets among children aged 2–36 months old in the Gaza Strip. The study sample consisted of 170 children with rickets and 170 control children. A questionnaire interview was used. Descriptive statistics, Chi-square, odd ratios and logistic regression were applied. Rickets was higher among children of unemployed mothers. Rickets was also higher among exclusively breast-fed children (OR = 2.3, *P* = 0.000). Early introduction of complementary food particularly that contains eggs or fishes protects against rickets. Children who were not exposed to sunlight had more rickets (OR = 16.3, *P* = 0.000). Rickets was higher with decreasing frequency of exposure to sunlight and among children who had been fully dressed. None of the control children were found to live in the basement compared to 11.8% cases. The more deliveries the mothers had, the more rickets was found among their children (*P* = 0.028). Rickets was higher among children of mothers who did not receive health education (OR = 41.3, *P* = 0.000). In conclusion, lack of sunlight exposure and health education, and exclusive breastfeeding were the major risk factors contributed to rickets among children in the Gaza Strip.

Keywords: children; Gaza Strip; nutritional rickets; risk factors.

INTRODUCTION

Nutritional rickets is a form of a metabolic bone disease resulting from vitamin D deficiency in children. It causes softening and weakening of bones because of defective or inadequate bone mineralisation (Kragballe, 2000). The clinical signs and symptoms of rickets include bowed legs, rachitic rosary, frontal bossing of the skull, widened wrist and ankle joints and poor

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growth (Feldman, 1990; Pugliese et al., 1998; Soliman et al., 2009).

Nutritional rickets remains a public health problem in many countries, despite dramatic declines in the prevalence of the condition in many developed countries since the discoveries of vitamin D and the role of ultraviolet light in prevention. The disease continues to be problematic among infants in many communities, especially among infants who are exclusively breast-fed without vitamin D supplementation (Binet and Kooh, 1996), infants and their mothers in the Middle East (Al Jurayyan et al., 2002) and infants and children in many developing countries (Thacher et al., 2006).

Lack of sunlight exposure, inappropriate dietary intake and poor housing would contribute to the development of rickets (Crocombe et al., 2004; Matsuo et al., 2009; Rajakumar, 2003). Exposure to sunlight particularly at morning hours and early introduction of vitamin D rich weaning food would prevent rickets among children (Dagnelie et al., 1990). However, the fortification of milk with vitamin D is the best guarantee that children will meet their vitamin D needs in addition to other cereals and child food products may be fortified with vitamin D (Whitney et al., 2007).

In the Gaza Strip rickets continues to be a public health problem despite abundance of sunshine most of the year. The health status of children as vulnerable group may come to a point with the worse situation in the Gaza Strip since several decades due to increasing poverty and the still ongoing suffering. To our knowledge, one unpublished report estimated the prevalence of rickets in the Gaza Strip to be 12.5% (Abo Jahal, 1996). In addition, no published data are available on the various aspects of risk factors associated with nutritional rickets in the Gaza Strip. Therefore, the rationale reside behind the present study is to identify in detail the risk factors associated with nutritional rickets among children less than three years old in the Gaza Strip. The importance of early recognition of such contributing risk factors and treatment of rickets may prevent subsequent bone damage and fractures and the complications of late onset respiratory distress and delayed growth.

MATERIALS AND METHODS

Study design and target population

This investigation was a case control study. The target population was the rachitic children from Al-Shatea Medical Clinic in Gaza City; the principal center for rickets in the Gaza Strip.

Sample size

The Sample size calculations were based on the formula for case-control studies (Fleiss, 1981). EPI-INFO statistical package version 3.5.1 was used with 95% CI, 80% power, 50% proportion as conservative and OR = 2. The sample size in case of 1:1 ratio of case control was found to be 148:148. Based on our response expectation of 90%, we multiply 148 by 1.11 (100/90). Therefore, the required sample size was found to be 164. For a no-response expectation, the sample size was increased to 170 children. The controls were also 170 children.

Sampling

Children aged 2–36 months old without history of other diseases at their first examination who were referred to Al-Shatea Medical Clinic in Gaza City, and whom diagnosis were confirmed by radiography and few biochemical tests as rachitic patients were selected. Control children were selected from cases' neighbours and from cases' siblings of different mothers lived in separate houses. Their medical history and physical examination confirmed that they did not have rickets. Case and control children were matched for age and gender. For ethical consideration, the necessary approval to conduct this study was obtained from Helsinki committee in the Gaza Strip.

Questionnaire interview

A meeting interview was used for filling in the questionnaire for the child's mother of both cases and controls. All interviews were conducted face to face. The questionnaire was based on the child healthcare centre questions related to child's personal data, breastfeeding, type of child' food and sunlight exposure, with some modifications. Most questions were one of two types: the yes/no question, which offers a dichotomous choice and the multiple choice question, which offers several fixed alternatives (Backestrom and Hursh-Cesar, 1981). The questionnaire was validated by four specialists in the fields of nutrition, environment and public health. A questionnaire was piloted with 10 children' mothers not included in the sample from the study area, and modified as necessary for improving reliability. The modified questionnaire included information on personal profile of the study population and their mothers such as age, sex, years of education and occupation for child's mother; breastfeeding (exclusive and non-exclusive) and its duration; age of introducing complementary food; selective type of consumed food for both child and mother for example, egg, fish and milk; sunlight exposure usually at the morning hours either indoors or outdoors; housing either living in the basement (the lowermost portion of a structure partly or wholly below ground level), in a flat (a suite of rooms designed as a residence and generally located in a building occupied by more than one household) or in a villa (a luxury private house composed usually of two floors and surrounds by a garden); number of deliveries and mother health education which means the part of healthcare that is concern with promoting health behaviour.

Data analysis

Data were computer analysed using SPSS/PC (Statistical Package for the Social Science Inc. Chicago, Illinois USA, version 13.0) statistical package. Simple distribution of the study variables and the cross tabulation were applied. Chi-square (^{2}) was used to identify the significance of the relations, associations, and interactions among various variables. Yates's continuity correction test, ^{2} (corrected), was used when not more than 20% of the cells had an expected frequency of less than five and when the expected numbers were small. Odd Ratios (OR) were applied to explore the magnitude of the difference between cases and controls variables of our concern (Kirkwood, 1988; Kuzma, 1992). Logistic regression by Backward stepwise method was also used. The model was accounted for 85% of variation in the dependent variable (85%). The result was accepted as statistically significant when the p-value was less than 5% ($p < 0.05$).

RESULTS

The average age of the control children (n = 170) was 15.1 ± 9.6 months old where as that of cases (n = 170) was 14.9 ± 6.7 months old.

Distribution of rickets among children by mothers' personal profile

As indicated in Table 1, analysis of the educational status of the mothers showed that 8(4.7%) and 19(11.2%) mothers of controls and cases had less than six years of education, 134(78.8%) and 139(81.8%) mothers had 6–12 years of education and

28(16.5%) and 12(7.0%) were educated for more than 12 years. The maternal education period showed significant difference between mothers of controls and cases (^{2} = 10.97, *P* = 0.004), with rickets was more prevalent among children of less educated mothers. Regarding mother's occupation, the majority of mothers were unemployed. The employed mothers of control children were 28(16.5%) whereas only one rachitic child's mother (0.6%) was employed. Significant difference was found between the two groups (^{2} corrected = 25.48, *P* = 0.000), with more prevalent rickets among children of unemployed mothers.

Distribution of rickets among children by breastfeeding, its duration and start of complementary food

Table 2 showed that 111(65.3%) of controls and 138(81.2%) of cases were exclusively breast-fed. However, 59(34.7%) controls and 32(18.8%) cases were non-exclusively breast-fed. Rickets was more likely 2.3 times significantly higher among exclusively breast-fed children than among those who were non-exclusively breast-fed (OR = 2.3, *P* = 0.000). A total of 116(71.6%) controls and 91(58.0%) cases were breast-fed for one year or less and 46(28.4%) controls and 66(42.0%) cases were breast-fed for more than one year. Rickets was also found to be higher among children even with longer duration of breastfeeding (^{2} = 6.19, *P* = 0.013). The majority of controls 141(82.9%) received their complementary food during the first six months compared to 99(58.2%) cases. Children who received their complementary food after six months were 29(17.1%) controls and 71(41.8%) cases. Significant difference was also found between both groups (^{2} = 24.99, *P* = 0.000) indicating that early introduction of complementary food (starts at three months as reported by mothers) has a protective effect against rickets.

Distribution of rickets among children by selective type of food

Table 3 pointed out that 60(35.3%), 72(42.4%) and 38(22.4%) of control children did not receive eggs, fishes and milk, respectively compared to their counterparts of 80(47.1%), 91(53.5%) and 72(42.4%)

Table 1 Distribution of rickets among children by mothers' personal profile

Mother personal profile	Controls (n = 170) No. (%)	Cases (n = 170) No. (%)	P-value
Age (year)			
<24	55(32.4)	52(30.6)	0.939
24–28	51(30.0)	52(30.6)	
>28	64(37.6)	66(38.8)	
Education (year)			
<6	8(4.7)	19(11.2)	0.004
6–12	134(78.8)	139(81.8)	
>12	28(16.5)	12(7.0)	
Occupation			
Unemployed	142(83.5)	169(99.4)	0.000*
Employed	28(16.5)	1(0.6)	

**P*-value of $^{2}_{(corrected)}$ test

Table 2 Distribution of rickets among children by breastfeeding, its duration and start of complementary food as reported by mothers

Child feeding	Controls (n = 170) No. (%)	Cases (n = 170) No. (%)	P-value
Breastfeeding			
Exclusive*	111(65.3)	138(81.2)	0.000
Non-exclusive**	59(34.7)	32(18.8)	
Duration of breastfeeding			
≤12 months	116(71.6)	91(58.0)	0.013
>12 months	46(28.4)	66(42.0)	
Start of complementary food			
<6 months***	141(82.9)	99(58.2)	0.000
>6 months	29(17.1)	71(41.8)	

**Exclusive breastfeeding*: only breast milk, no other liquid or solid from any other source enters the child's mouth (Labbok, 2000).

***Non-exclusive breastfeeding*: children received drinks/foods with breast milk.

***Starts at three months as reported by mothers.

Table 3 Distribution of rickets among children by children's selective type of food as reported by mothers

Food	Controls (n = 170) No. (%)	Cases (n = 170) No. (%)	P-value
Eggs			
Yes	110(64.7)	90(52.9)	0.028
No	60(35.3)	80(47.1)	
Fishes			
Yes	98(57.6)	79(46.5)	0.039
No	72(42.4)	91(53.5)	
Milk			
Yes	132(77.6)	98(57.6)	0.000
No	38(22.4)	72(42.4)	
Yogurt			
Yes	140(82.4)	110(64.7)	0.000
No	30(17.6)	60(35.3)	
Fruits and vegetables			
Yes	141(82.9)	128(75.3)	0.083
No	29(17.1)	42(24.7)	

with ^{2} = 4.86, P = 0.028, ^{2} = 4.25, P = 0.039, ^{2} = 21.91, P = 0.000, respectively. On the other hand, mothers of control children who did not consume the above food stuff were 31(18.2%), 37(21.8%) and 55(32.4%), respectively compared to 84(49.4%), 56(32.9%) and 84(49.4%) mothers of cases as indicated in Table 4 (^{2} = 36.91, P = 0.000, ^{2} = 5.34, P = 0.021 and ^{2} = 11.37, P = 0.001, respectively). These results imply that consumption of such food stuff protect against the development of rickets.

Table 4 Distribution of rickets among children by mothers' selective type of food

Food	Controls (n = 170) No. (%)	Cases (n = 170) No. (%)	P-value
Eggs			
Yes	139(81.8)	86(50.6)	0.000
No	31(18.2)	84(49.4)	
Fishes			
Yes	133(78.2)	114(67.1)	0.021
No	37(21.8)	56(32.9)	
Milk			
Yes	115(67.6)	86(50.6)	0.001
No	55(32.4)	84(49.4)	
Fruits and vegetables			
Yes	168(98.8)	159(93.5)	0.024*
No	2(1.2)	11(6.5)	

**P*-value of $^{2}_{(corrected)}$ test.

Table 5 Distribution of rickets among children by sunlight exposure

Sunlight exposure*	Controls (n = 170) No. (%)	Cases (n = 170) No. (%)	P-value
Child			
Yes	155(91.2)	66(38.8)	0.000
No	15(8.8)	104(61.2)	
Mother			
Yes	132(77.6)	54(31.8)	0.000
No	38(22.4)	116(68.2)	

*Sunlight exposure usually at the morning hours either indoors or outdoors.

Distribution of rickets among children by sunlight exposure

The control and case children who were exposed to sunlight were 155(91.2%) and 66(38.8%) compared to 15(8.8%) and 104(61.2%) who were not exposed (Table 5). Significant difference was found between the two groups (^{2} = 102.4, P = 0.000) with rickets was more likely 16.3 times higher among non-exposed children [OR = 16.3, 95% CI (8.5–31.6)]. For mothers, 132(77.6%) and 54(31.8%) mothers of control and case children were exposed to sunlight compared to 38(22.4%) and 116(68.2%) who were not exposed. Also, significant difference was recorded (^{2} = 72.2, P = 0.000) with rickets was more likely 7.5 times higher among children of non-exposed mothers [OR = 7.5, 95% CI (4.5–12.5)]. These results indicate that lack of sunlight exposure is a key factor in rickets development.

Distribution of rickets among children by frequency of sunlight exposure and clothing

As illustrated in Table 6, children who were exposed daily to sunlight were 86(55.5%) controls and 1(1.5%) cases, who were exposed 2–3 day/week were 54(34.8%) and 27(40.9%) and who were exposed weekly were 15(9.7%) and 38(57.6%). Significance difference was recorded between groups (^{2} = 79.0, P = 0.000) with increasing rickets

Table 6 Distribution of rickets among children by frequency of sunlight exposure and clothing as reported by mothers

Sunlight exposure	Controls (n = 155) No. (%)	Cases (n = 66) No. (%)	P-value
Frequency of exposure			
Daily	86(55.5%)	1(1.5%)	0.000
2–3 day/week	54(34.8%)	27(40.9%)	
Weekly	15(9.7%)	38(57.6%)	
Clothing			
Diaper only	15(9.7%)	2(3.0%)	0.000
Fully dressed	16(10.3%)	43(65.2%)	
Exposing certain areas	124(80.0%)	21(31.8%)	

among children as frequency of sunlight exposure decreased. Concerning clothing, children who wear diaper only were 15(9.7%) controls and 2(3.0%) cases, who had been fully dressed at the time of exposure were 16(10.3%) and 43(65.2%) and who had certain areas been exposed were 124(80.0%) and 21(31.8%). Significant difference was also found (^{2} = 162.03, P = 0.000). The conclusion is that, the longer duration of exposure to sunlight combined with being undressed is an important factor in the prevention of rickets.

Distribution of rickets among children by house type and sunlit hours per day

Table 7 demonstrates that children who lived in flat were 155(91.2%) controls and 111(65.3%) cases and those who lived in villa were 8(4.7%) and 25(14.7%). None of the control children were found to live in the basement compared to 20(11.8%) cases. The remaining children who lived in other places for example, crowded camps constituted 7(4.1%) controls and 14(8.2%) cases. Significance difference was found between groups (^{2} = 38.37, P = 0.000). Concerning the daily sun hours their houses being sunlit, 30(17.6%) of controls' houses were being sunlit ≤3 hr/day contrary to 88(51.8%) cases' houses. However, 140(82.4%) controls' houses were being sunlit for >3 hr/day in contrary to 82(48.2%) cases' houses (^{2} = 43.66, P = 0.000). This supports the above results that sunlight is an important determinant of rickets.

Distribution of rickets among children by number of deliveries and receiving health education

As depicted from Table 8, mothers of control children who had ≤3, 4–6 and >6 deliveries were 90(52.9%), 65(38.3%) and 15(8.8%), respectively compared to 80(47.1%), 58(34.1%) and 32(18.8%) mothers of cases with rickets was higher with increasing number of deliveries (^{2} = 7.14, P = 0.028). A total of 155(91.2%) and 34(20.0%) mothers of controls and cases received health education compared to 15(8.8%) and 136(80.0%) who did not. Significant difference was found between the two groups (^{2} = 174.4, P = 0.000) with rickets was more likely 41.3 times higher among children of mothers who did not receive health education [OR = 41.3, 95% CI (20.7–83.9)]. This indicates that health education of the child's mother plays a major role in preventing rickets.

Table 7 Distribution of rickets among children by type of house and sunlit hours per day as reported by mothers

Housing	Controls (n = 170) No. (%)	Cases (n = 170) No. (%)	P-value
House type*			
Basement	0(0.0%)	20(11.8%)	0.000
Flat	155(91.2%)	111(65.3%)	
Villa	8(4.7%)	25(14.7%)	
Others	7(4.1%)	14(8.2%)	
Sunlit hours/day			
≤3 hr	30(17.6%)	88(51.8%)	0.000
>3 hr	140(82.4%)	82(48.2%)	

**Basement*: the lowermost portion of a structure partly or wholly below ground level, flat: a suite of rooms designed as a residence and generally located in a building occupied by more than one household, villa: a luxury private house composed usually of two floors and surrounds by a garden, others: places like crowded camps.

Table 8 Distribution of rickets among children by number of deliveries and mothers' health education

Variable	Controls (n = 170) No. (%)	Cases (n = 170) No. (%)	P-value
Number of deliveries			
≤3	90(52.9%)	80(47.1%)	0.028
4–6	65(38.3%)	58(34.1%)	
>6	15(8.8%)	32(18.8%)	
Health education*			
Yes	155(91.2%)	34(20.0%)	0.000
No	15(8.8%)	136(80.0%)	

*Health education means the part of healthcare that is concern with promoting health behaviour.

Table 9 Logistic regression model for independent variables

Factor (Yes vs No)	P-value	OR*	OR with 95% CI	
			Lower	Upper
Mother occupation	0.015	0.013	0.000	0.429
Exclusive breastfeeding	0.001	15.512	3.272	73.551
Duration of breastfeeding	0.001	1.482	1.183	1.858
Start of complementary food	0.000	1.833	1.328	2.530
Eggs consumed by children	0.000	0.009	0.001	0.084
Eggs consumed by mother	0.046	0.217	0.048	0.976
Fish consumed by mother	0.010	0.190	0.053	0.675
Child exposure to sunlight	0.000	0.001	0.000	0.015
Number of deliveries	0.051	1.418	1.000	2.014
Health education	0.000	0.004	0.001	0.030

*Adjusted odd ratio.

Logistic regression model for independent variables

As indicated in Table 9, the adjusted odd ratios with 95% CI for all independent variables revealed that the factors predicted to be associated with rickets in the Gaza Strip were mother occupation, exclusive breastfeeding and its duration, start of complementary food, eggs consumed by children and mothers, fish consumed by mother, child exposure to sunlight, number of deliveries and health education.

DISCUSSION

Nutritional rickets remains a major health problem for children in many regions of the world including Gaza Strip. The etiopathogenesis of rickets is thought to be multifactorial. This study is an attempt to assess various risk factors contributed to the disease. Rickets was higher among children of less educated mothers. Although this gradient effect disappeared when adjusting for other independent variables, it merely reflects the fact that maternal illiteracy could contribute not only to rickets but also to other different health related behaviours and problems (Abed, 1992). The association of rickets with lower education of the child caretaker was documented (Chali, 1998). Regarding mother occupation, rickets was found to be higher among children of unemployed mothers. The gradient effect of mother occupation persists when adjusting for other independent variables. The economical situation in Gaza strip is very bad particularly after the imposed siege. Market prices are tripled and the unemployment crises are being raised. This declined the purchasing power making children more vulnerable to nutritional rickets.

In comparison to non-exclusive breastfeeding, exclusive breastfeeding was more associated with rickets. The gradient effect of exclusive breastfeeding persists when adjusting for other independent variables. Similar results were reported (Siddiqui and Rai, 2005; Weisberg et al., 2004). Human milk contains a vitamin D concentration of ≤25 IU/L making it a low source of vitamin D (Lammi-Keefe, 1995). Infants who are breast-fed but do not receive supplemental vitamin D or adequate sunlight exposure are at increased risk of developing rickets (Binet and Kooh, 1996; Fida, 2003). However, in light of growing concerns about sunlight and skin cancer, it seems prudent to recommend that all breast-fed infants be given supplemental vitamin D (Lawrence et al., 2003). It is interesting to find out that rickets was more frequent even among children who were breast-fed for more than one year that is, the longer duration of breastfeeding, the higher frequency of rickets. The gradient effect of breastfeeding duration also persists. However, exclusive breastfeeding was not reported within a time frame and this needs further investigation. Exclusive breastfeeding beyond six months without vitamin D supplementation was identified as a risk factor for rickets in children (Dagnelie et al., 1990). In Alaska, the contribution of breastfeeding to vitamin D deficiency has likely increased in recent years with an increase in the proportion of women who breast feed longer than six months from 28% of infants during 1990 to 50% during 2000 (Bruce and Middaugh, 2003).

The recent breastfeeding promotion may have led to the belief that the exclusive breast-fed infant is in need of no further supplements. However, this belief does not coincide with our finding that the early introduction of complementary food (starts at three months as reported by mothers) has a protective effect against rickets. The gradient effect of introducing complementary food persists when adjusting for other independent variables. Low rate of rickets was reported among children whom their mothers have better and improved child rearing practices in terms of being more aware of the weaning food, its quality and the appreciate age for starting to wean (Molla et al., 2000). Delayed complementary feeding may lead to a breast milk depended child who prefers breast milk over complementary food. Nevertheless, the exact age at which to introduce complementary food, duration of complementary, appropriate frequency of feeding, content and factors affecting intake of complementary food are beyond the scope of the current study and require further investigation.

As reported by mothers, rickets was more frequent among children who did not receive eggs, fishes and milk. In our culture most of mothers either stayed with their children or taking care of them most of the time. So, they can easily recall what they fed their children even since long period of time which minimise the recall bias. This result was true for children whom their mothers did not consume the same food stuff. Only the gradient effect of egg and fish persists. However, foods consumed were not reported within a time frame and this needs further investigation. Such food stuff are exogenous sources of vitamin D (Balch, 2001; Stroud et al., 2008). Therefore, consumption of the above food stuff protects against the development of rickets. A previous study revealed high prevalence of vitamin D deficiency among nursing mothers without fish in their diet (Ahmad et al., 1995). Most of Palestinian people specially the poor ones consume inadequate amount of fish due to its high price. Instead mothers could depend on eggs, milk and its derivatives as available and cheap source of vitamin D to feed herself and her child. However, economical, social and cultural factors should not be excluded.

Rickets was higher in children who were not exposed to sunlight than in those who were exposed. This was also true for children whom their mothers were not exposed to sunlight implying that sunlight exposure is a key factor in the development of vitamin D deficiency rickets. The gradient effect of child exposure to sunlight persists when adjusting for other independent variables. It is known that endogenous vitamin D is produced in the skin from sunlight exposure (Kragballe, 2000). However, many factors in health related behaviour for good and ill, are operated and result in decrease production of vitamin D in the skin. Fear of the sun especially in summer is based on the community knowledge of sunstroke. This fear may become exaggerated, and measures are taken to avoid direct sunlight. During winter measures are taken to avoid an open well-ventilated place to protect the child from drafts and then common cold or respiratory infection. Therefore, women intended to dress their children heavy clothes, moreover, infants are wrapped for long period of time. Thus, clothes absorb most ultraviolet radiation and this will prevent the cutaneous production of vitamin D (Matsuoka et al., 1992). Many studies showed that lack of sunlight exposure increases the risk of rickets (Matsuo et al., 2009; Molla et al., 2000; Oliveri et al., 1993).

Distribution of rickets among children was decreased with increasing frequency of exposure to sunlight. The more the times the child had been exposed to sunlight, the more production of vitamin D in the skin. Similar results were obtained (Chali, 1998; Specker et al., 1985). Therefore, mothers are strongly advice to expose their children daily to sunlight. In this context, distribution of rickets was higher among children who had been fully dressed than those who had been worn diaper only or children to whom certain areas had been exposed during the time of exposure. In the case of complete wrapping of the child, the skin source of vitamin D becomes cut off. Breast milk being a weak source of vitamin D, the neonate becomes gradually depleted of all vitamin D and thus clinical signs of rickets appear sometimes later (Molla et al., 2000). Traditional cultural habits had an effect on sunlight exposure that will decrease vitamin D synthesis in the skin (Wondale et al., 2005). The above results are supported with the conclusion that increase frequency of exposure to sunlight combined with being undressed is an important factor in the prevention of rickets (Matsuoka et al., 1992).

Regarding house type, none of the control children were found to live in the basement compared to 11.8% cases. Of course lack of sunlight exposure is the major cause reside behind such finding. Children lived in flats were also found more likely to have rickets. Urbanisation may lead to more congested living, less space, external courtyard (Fitzpatrick, 2000). In addition, fear of accidents whether car accidents or falling down make parents not to allow their children to play either outdoors or in the veranda and this restricts their access to sunlight exposure. In Saudi Arabia, a survey showed lower serum 25-hydroxy vitamin D levels in urban areas than in rural areas, lower levels were among occupants of mud or brick houses than tents (Sedrani, 1984). The sunlight enters frequently tents better than mud or brick houses. This supports our finding that the longer duration the house being sunlit, the lower prevalence of rickets among children.

Our results revealed that the more deliveries the mothers had, the more rickets was found among their children. The gradient effect of deliveries number persists but with P value at the border line of significance (P = 0.051). This could be attributed to the idea that increase number of deliveries may be associated with increase mother dietary intake. Despite that, increase number of siblings affect vitamin D, it may be a cause for vitamin D deficiency leading to nutritional rickets (Ahmad et al., 1995; Dratva et al., 2006; Molla et al., 2000). In addition association between obstetric factors and vitamin D deficiency rickets was reported (Beser and Cakmakci, 1994). In view of this finding, the mother may not have enough time to replete her nutritional status particularly vitamin D and calcium after pregnancy, and she enters the next pregnancy in a worse state. Additionally, baby of such mother has little vitamin D stored in the liver, breast milk provides little more and then rickets occurred (Wharton, 1992). Hence, health education programs to enhance woman awareness on frequent pregnancy would be fruitful. The necessity of such health education was obvious when we found that rickets was more likely 41.3 times higher among children of mothers who did not receive health education. The gradient effect of health education persists when adjusting for other independent variables. Mothers, who had sought advice from both doctors and mother- and child-care workers, were found to have the lowest number of rachitic children (Dratva et al., 2006). A concerted effort is needed to develop health education programs that will result in mothers' behaviour changes. In conclusion, lack of sunlight exposure and health education, and exclusive breastfeeding were the major risk factors contributed to rickets among children in the Gaza Strip.

BIOGRAPHY

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